Appendix B

ARB Air Pollutant Summaries

September 12, 2000

Appendix B. ARB Air Pollutant Summaries

B.1 Introduction

The following is a concise summary of each air pollutant with information on air quality, trends, emissions, and sources. Air quality and trends information is reported as peak indicator values for California. This value represents the maximum concentration expected to occur once per year and is based on a statistical calculation incorporating ambient data collected at each monitoring site throughout the state. This value is considered to be a robust statistical calculation that offers a stable concentration that is not highly influenced by year-to-year changes in meteorology. Maximum concentrations are presented for sulfates. All values on the x-axis are in years. For further information regarding air quality, trends, and emissions for specific locations throughout the State, including information on site openings, site closures, and data completeness, the reader is referred to the ARB website at www.arb.ca.gov and www.arb.ca.gov/aqd/almanac/almanac99.htm. The information is also available from the ARB's Planning and Technical Support Division by calling 916-323-8482.

Indoor and outdoor air pollutant exposures in California are also summarized in this Appendix for the studies that provided parallel monitoring. However, note that the averaging times for the pollutants in many cases were not the averaging times for the ambient air quality standards. The information provides some relative comparisons for indoor and outdoor concentrations for the pollutants measured.

B.2 Ozone

B.2.1 Introduction

Ozone is a colorless gas with a pungent odor. It is the chief component of urban smog. Ozone is not directly emitted as a pollutant, but is formed in the atmosphere when hydrocarbon and NO_x precursor emissions react in the presence of sunlight. Meteorology and terrain play major roles in ozone formation. Generally, low wind speeds or stagnant air coupled with warm temperatures and cloudless skies provide for the optimum ozone conditions. As a result, summer is generally the peak ozone season. Because of the reaction time involved, peak ozone concentrations often occur far downwind of the precursor emissions. Therefore, ozone is a regional pollutant that often impacts a widespread area.

B.2.2 Air Quality, Emissions, and Sources

Air quality with respect to ozone has improved greatly in all areas of California over the last 19 years, despite significant population growth. The statewide trend is illustrated in **Figure B.2-1**, and principally reflects values for the Southern California area. The maximum peak 1-hour indicator declined 53 percent from 1980 to 1999. During this same time period, however, the State's population has grown by about 41 percent and the number of vehicle miles traveled each day has increased by about 78 percent. Motor vehicles are the largest source of hydrocarbon precursor emissions as illustrated in **Figure B.2-2**, followed by stationary source emissions. Motor vehicles are also the largest source of NOx precursor emissions as illustrated in Figure B.4-2. Reducing vehicular emissions with ARB's low emission vehicle standards will help to reduce ROGs considerably. However, increases in population and driving will partially offset the benefits of cleaner vehicles. In addition to motor vehicle controls, the ARB is establishing controls for other sources of ozone precursor emissions, such as consumer products. The ARB and other agencies are also investigating new approaches such as implementing market incentives to improve air quality.

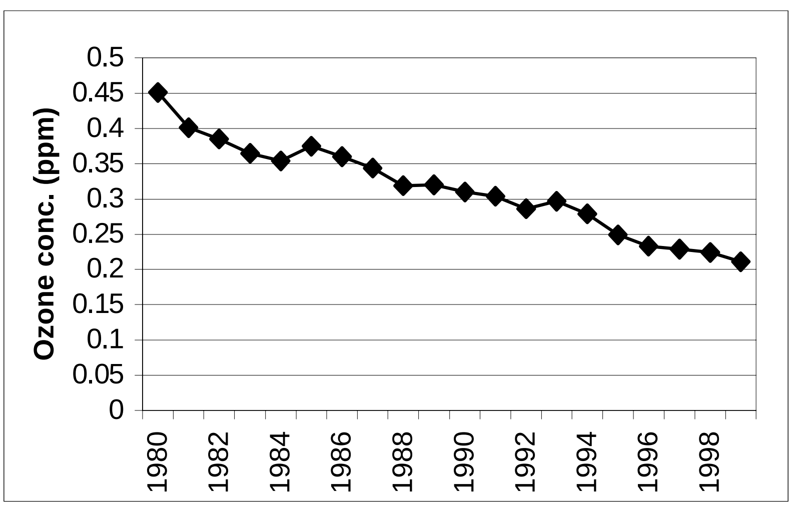

Figure B.2-1. Peak indicator for statewide ozone concentrations from 1980 through 1999 (ppm).

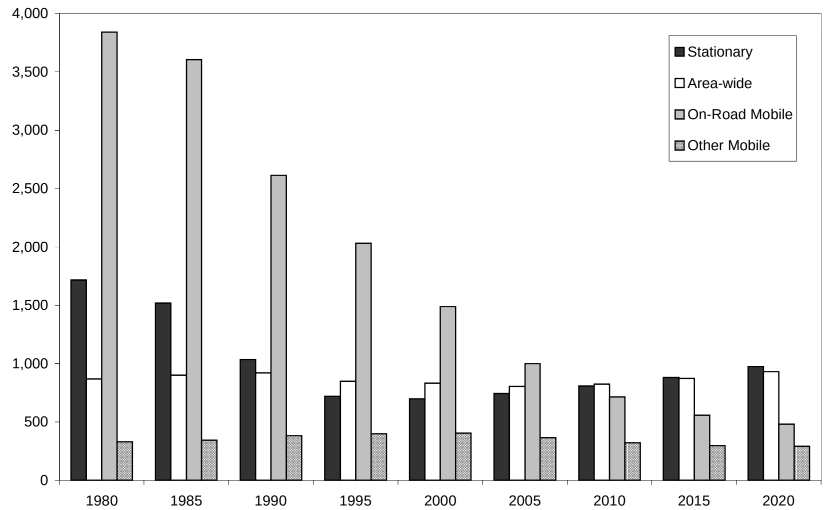

Figure B.2-2. Emissions (tons/day) and sources of reactive organic gases (ROG) that form ozone

B.3 Carbon Monoxide (CO)

B.3.1 Introduction

Carbon monoxide is a colorless and odorless gas that is directly emitted as a product of incomplete combustion. The highest concentrations are generally associated with cold stagnant weather conditions that occur during winter. In contrast to ozone, which tends to be a regional pollutant, CO problems tend to be localized.

B.3.2 Air Quality, Sources, and Emissions

The peak indicator for carbon monoxide concentrations statewide is illustrated in Figure B.3-1. As with ozone, carbon monoxide concentrations in all areas of California have decreased substantially over the last 19 years. Statewide, the maximum peak 8-hour indicator declined 35 percent from 1980 to 1999. Currently, the State carbon monoxide standard is violated in two areas: the South Coast Air Basin portion of Los Angeles County and the city of Calexico, in Imperial County.

The emissions for carbon monoxide are predominantly from mobile sources, followed by area-wide and other mobile sources as illustrated in Figure B.3-2. By year 2015, the sources, including mobile, are all projected to be similar in emissions as

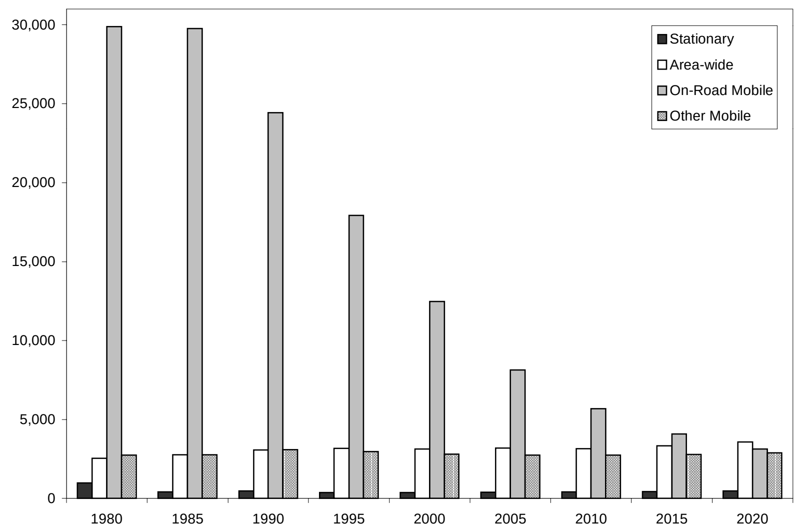

Figure B.3-1 Maximum 8-hr peak indicator carbon monoxide (ppm).tons per day.

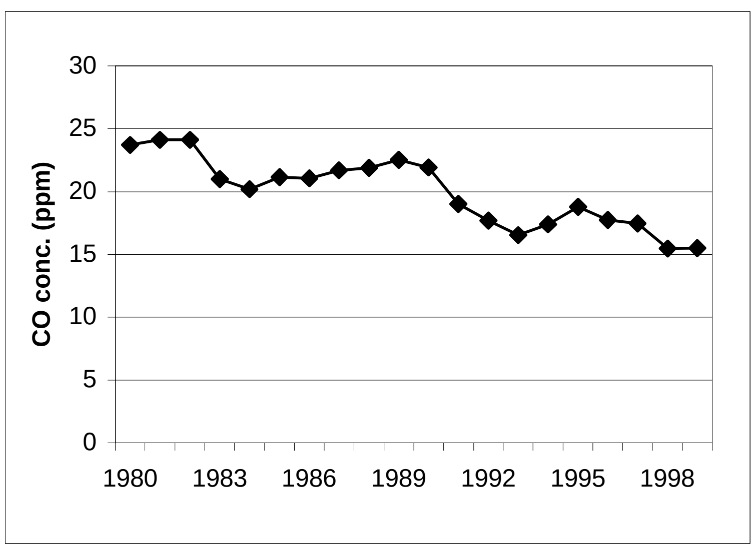

Figure B.3-2. Emissions (tons/day) and sources for carbon monoxide.

B.4 Nitrogen Dioxide (NO_2)

B.4.1 Introduction

Nitrogen dioxide (NO_2) is a red-brown gas that is derived from both direct emissions (generally from the combustion of fossil fuels) and from the conversion of nitric oxide (NO) to nitrogen dioxide (NO_2). During combustion, nitrogen, present as a major component of air, combines with oxygen to produce oxides of nitrogen. Both NO and NO_2 are important compounds in a series of chemical reactions in the ambient air to produce secondary compounds including ozone, nitrate aerosols, nitric acid, and other nitrogen-containing compounds that are toxic.

B.4.2 Air Quality, Sources, and Emissions

The concentrations of nitrogen dioxide have decreased by approximately 50% since 1980 as illustrated by the peak indicator concentrations in Figure B.4-1. The decrease is directly attributed to more stringent controls on both mobile and stationary sources.

The emissions of nitrogen dioxide are projected to decrease through 2020 with the emissions principally from mobile sources as illustrated in Figure B.4-2.

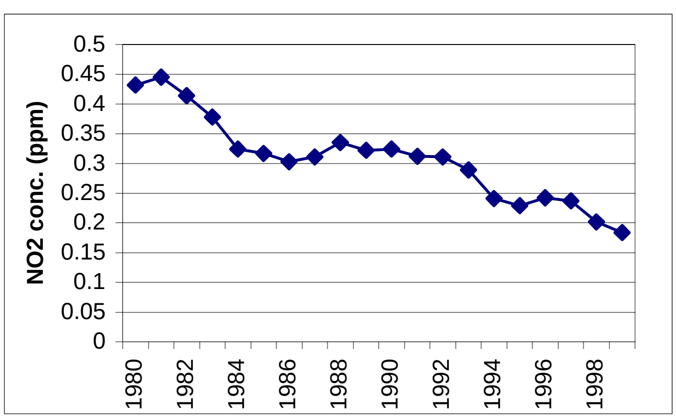

Figure B.4-1. Peak indicator concentrations for nitrogen dioxide (ppm).

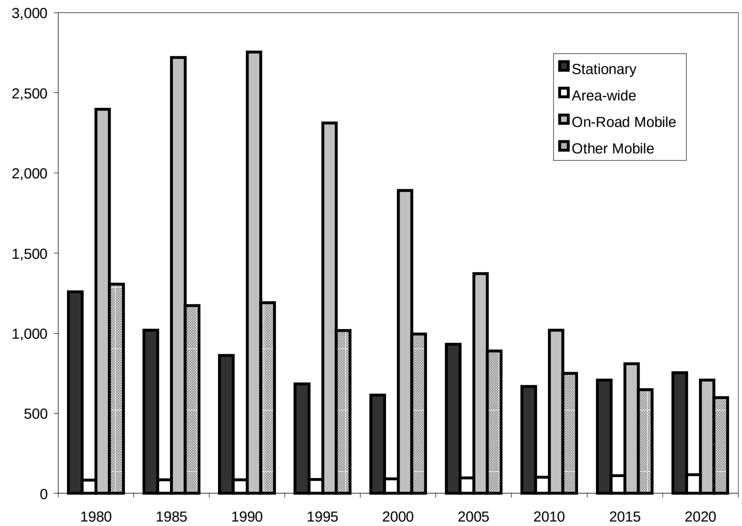

Figure B.4-2. Emissions (tons/day) and sources of nitrogen dioxide.

B.5 Airborne particulate matter (PM10)

B.5.1 Introduction

Airborne particulate matter with an aerodynamic diameter of 10 microns or less (PM10) is composed of a mixture of substances that includes elements (such as carbon, lead, nickel and iron), compounds (such as nitrates, sulfates, and polycyclic aromatic hydrocarbons), and complex mixtures (such as diesel exhaust and soil). Also present on particles are allergens and compounds derived from bacteria called endotoxins. Particles can be emitted directly into the atmosphere, such as from diesel vehicles, or can be formed gases that are transformed into particles through physical and chemical processes in the atmosphere (for example, nitrates from gaseous nitric acid).

B.5.2 Air Quality, Sources, and Emissions

Currently, over 99 percent of Californians breathe air that violates the State PM10 standards during at least part of the year. Consequently, particulate matter is receiving greater attention.

Peak indicator airborne concentrations of PM10 are illustrated in Figures B.5-1, B.5-2, and B.5-3. Peak indicator information illustrated in Figure B.5-1 incorporates all sites in California, and results in large peaks in 1990, 1994, and 1998. The influence of specific monitoring sites on these peaks and trends can be evaluated by re-analyzing data with and without specific sites. This analysis is illustrated in Figures B.5-2 and B.5-3. When the data from the Great Basin Valley sites are excluded from the analysis (Figure B.5-2), increases are observed in 1990, and an increasing trend is observed through 1999. The increase in 1994 therefore appears to have been influenced by the Great Basin Valley sites. When in addition to the Great Basin Valley sites, the Mojave dessert and Salton Sea sites are excluded from the analyses (Figure B.5-3), there are few increases observed, indicating that these sites also were responsible for the peak occurrences for certain years. The sources from the Great Basin, Mojave, and Salton Sea sites are thought to be wind-blown dust.

An analysis of the maximum annual geometric mean PM10 concentrations without the Great Basin Valley sites is presented in Figures B.5-4. There is a peak observed in 1996. The maximum annual geometric mean PM10 analysis without the Great Basin Valley, Mojave Dessert, and Salton Sea sites is illustrated in Figure B.5-5. The concentrations decrease throughout the years and there are no peak values observed. The Mojave and Salton Sea sites therefore contribute to the peak annual geometric mean PM10 concentrations observed in the State.

The emissions and sources of PM10 statewide are illustrated in Figure B.5-6. The most prominent source is “area-wide” that includes wind-blown dust, and dust from roadways. Activities that contribute to high PM10 can include wood burning, agricultural activities, and driving on unpaved roads. The PM10 concentrations do not relate well to population growth or vehicle usage, and high PM10 concentrations do not always occur in high population areas.

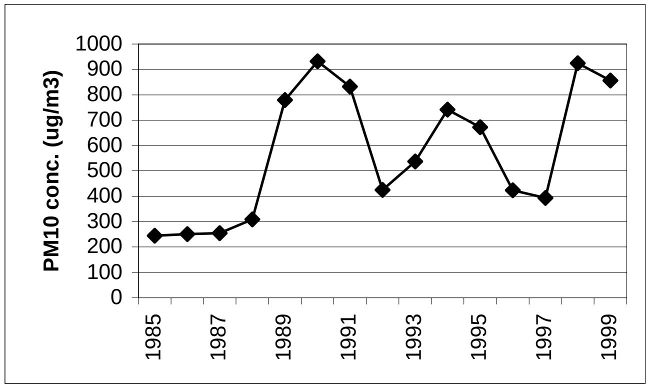

Figure B.5-1. Peak indicator for Statewide PM 10 (24-hour; $\mu g/m^3$).

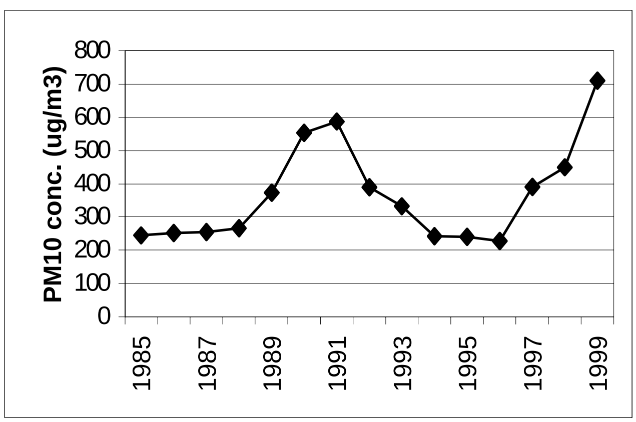

Figure B.5-2. Peak indicator for Statewide PM 10(24-hour; $\mu g/m^3$) not including Great Valley Basin sites

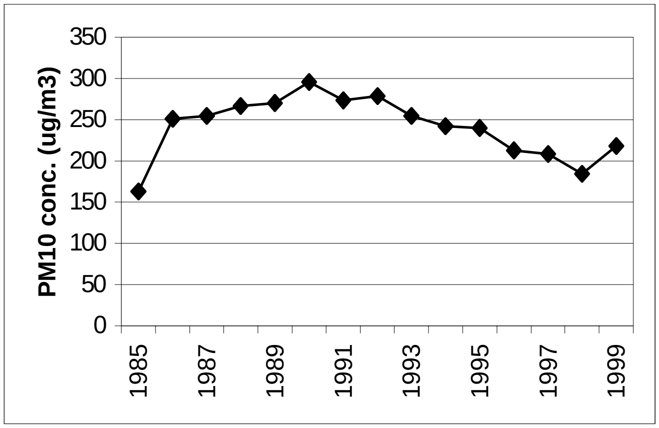

Figure B.5-3. Peak indicator for Statewide PM 10 (24-hour; μg/m^3) not including Great Basin Valley, Mojave Dessert, and Salton Sea sites.

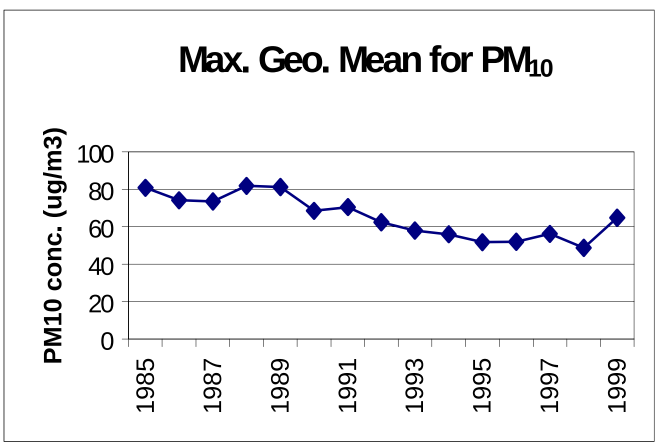

Figure B.5-4. Maximum annual geometric mean concentrations of PM10 not including the Great Basin Valley sites (μg/m^3).

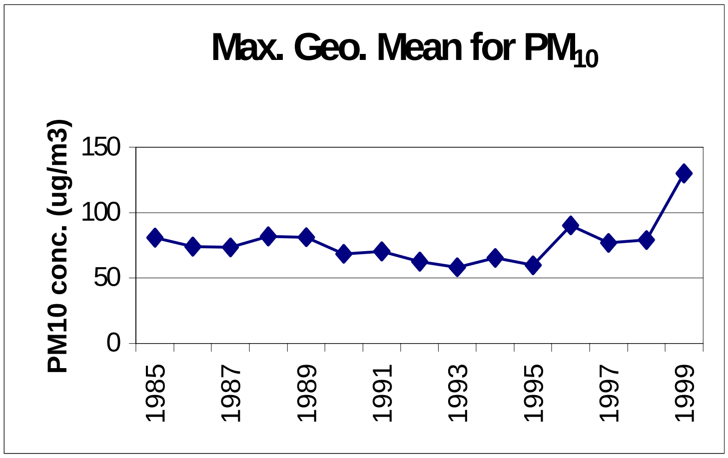

Figure B.5-5. Maximum annual geometric mean concentrations of PM10 not including the Great Basin Valley, Mojave Dessert, and Salton Sea sites ($\mu g/m^3$).

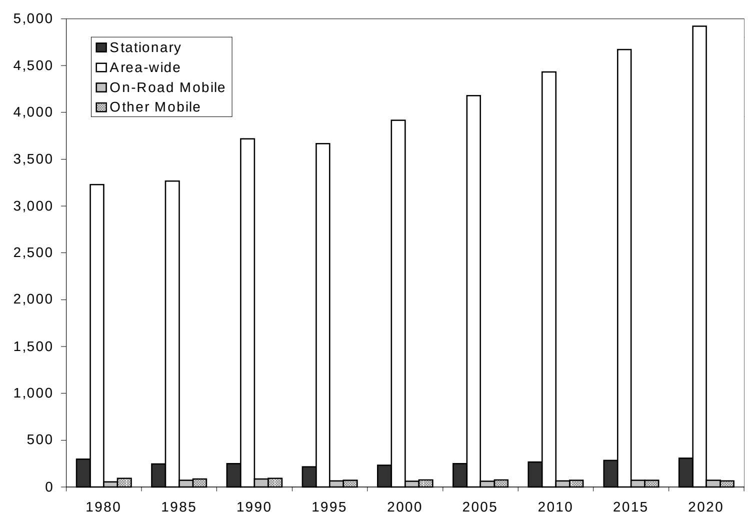

Figure B.5-6. Emissions (tons/day) and sources of PM10.

B.6 Lead (Pb)

B.6.1 Introduction

Lead (Pb) is a bluish-gray metal that occurs naturally in the earth's crust. Lead typically is present in the environment in combination with organic or inorganic compounds. Organic lead consists of compounds containing carbon, while inorganic lead consists of compounds containing lead but no carbon. Airborne lead in California is generally inorganic lead.

B.6.2 Air Quality

The maximum 30-day average concentrations of airborne lead are presented in Figure B.6-1. There has been a rapid decrease in airborne lead concentrations of lead due to removing lead from gasoline. This phase-out began during the 1970s, and subsequent ARB regulations have virtually eliminated all lead from the gasoline now sold in California. All areas of the State are currently designated as attainment for the State lead standard. Although the ambient lead standards are no longer violated, lead emissions from stationary sources still pose "hot spot" emissions in some areas. Because of this, the ARB identified lead as a toxic air contaminant (TAC) in 1997.

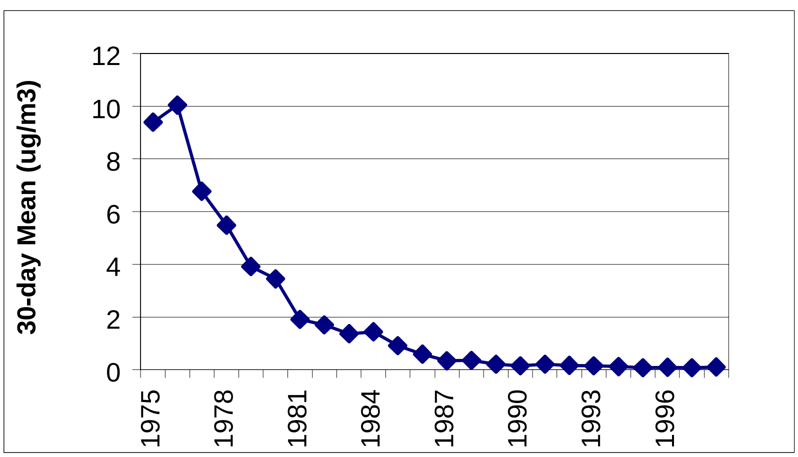

Figure B.6-1. Maximum 30-day average statewide lead concentrations ($\mu g/m^3$).

B.7 Sulfur Dioxide (SO_2)

B.7.1 Introduction

Sulfur dioxide (SO_2) is a colorless, non-flammable gas with a sulfurous odor. Sulfur dioxide is primarily produced from the combustion of sulfur-containing fuels and can be chemically transformed in the atmosphere into sulfuric acid and sulfates.

B.7.2 Air Quality, Sources, and Emissions

Sulfur dioxide emissions are from both mobile and stationary sources. While SO_2 poses significant problems in other parts of the nation such as the East Coast, emissions in California have been reduced sufficiently over the last 20 years so that all areas of California now attain both of the State standards for sulfur dioxide. The ambient concentrations of SO_2 have decreased over the last 20 years as illustrated in Figure B.7-1 for the peak indicator -1- hour SO_2 concentrations and illustrated in Figure B.7-2 for the peak indicator - 24-hour concentrations. The decrease is attributed to a number of control measures implemented during this time period including: 1) the use of alternative fuels such as natural gas; 2) the use of lower sulfur-containing fuels; and 3) emission controls on sources. The emissions and sources of SO_2 are illustrated in Figure B.7-3. The two source categories that have the highest, yet similar emissions starting from 1985 through 2020, are stationary and other mobile sources.

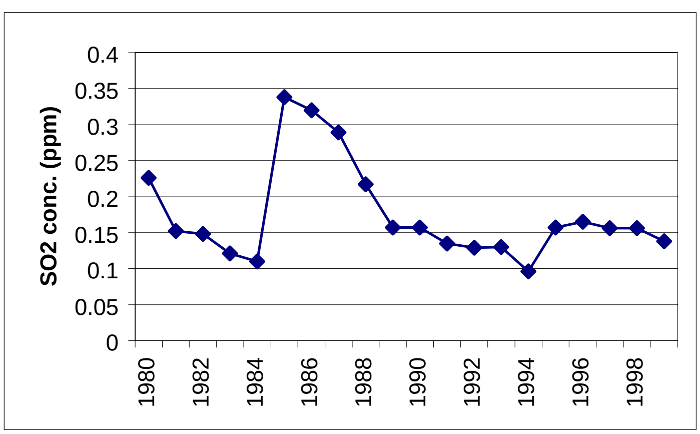

Figure B.7-1. Peak indicator value for sulfur dioxide (1-hour; ppm). Note that In 1985 a new site opened in Nipomo, San Luis Obispo near a petroleum reprocessing plant.

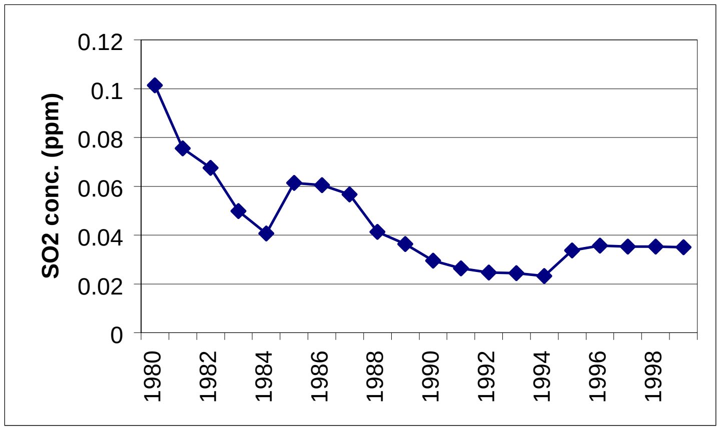

Figure B.7-2.   Peak indicator for sulfur dioxide (24-hour; ppm).

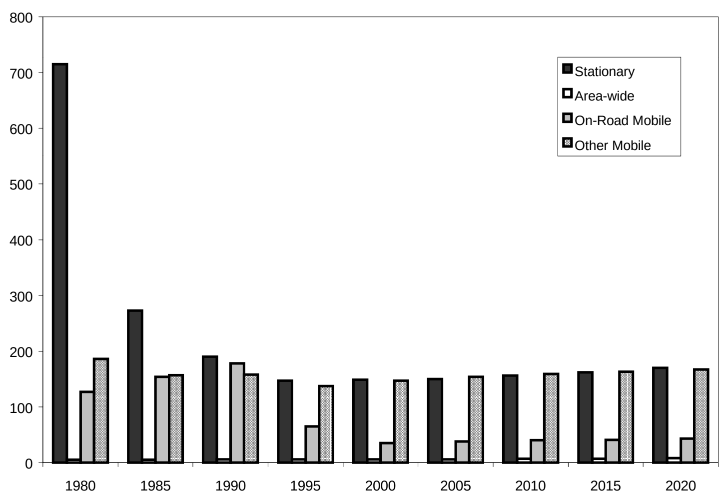

Figure B.7-3. Emissions (tons/day) and sources of sulfur dioxide (SO_2)

B.8 Sulfates

B.8.1 Introduction

Sulfates are present in the atmosphere typically in combination with other substances to form compounds such as ammonium sulfate and sulfuric acid. Sulfates are typically present on particulate matter that can be directly emitted (primary particles) or formed in the atmosphere (secondary particles). Examples of sources for primary sulfate particles include: dry lake beds, desert soils, and emissions from combustion of fossil fuels from stationary and mobile sources. Secondary sulfate particles are produced in the atmosphere from directly emitted oxides of sulfur (SOx). These SO_X emissions are generally from fossil fuel combustion. Secondary sulfate particles are transported over long distances.

B.8.2 Air Quality

Sulfate concentrations have steadily decreased in California, with some notable exceptions. The maximum concentration of sulfates for the years 1980 through 1999 is illustrated in Figure B.8-1. There is observed an increase in maximum concentration during 1995 and 1996. Following this increase, the maximum concentration is observed to be approximately 20-30 g/m^3. To evaluate the influence of a single site for the 1995-1996 increase, the highest maximum site (China Lake) was not included in the analysis. The results are presented in Figure B.8-2. When the China Lake site is not included in the analysis, a decreasing trend is observed.

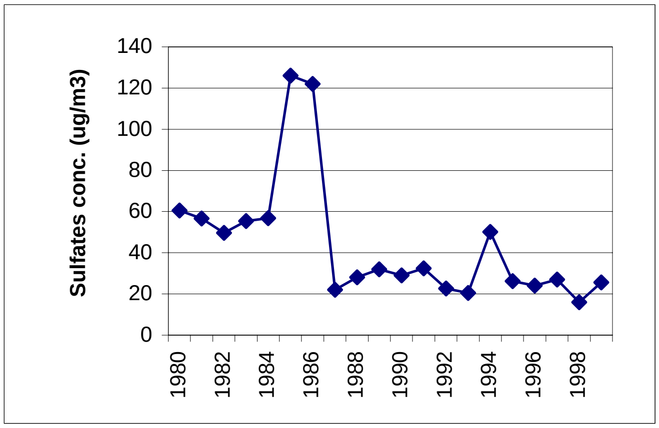

Figure B.8-1. Maximum concentration for sulfates (μg/m^3). All statewide sites.

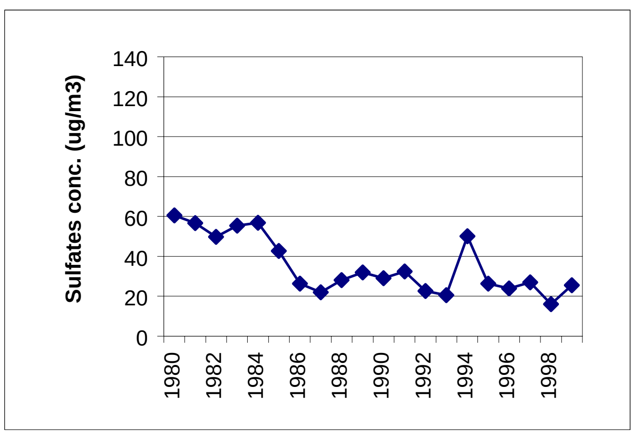

Figure B.8-2 . Maximum concentration for sulfates not including the China Lake site (μg/m^3).

B.9 Hydrogen Sulfide (H_2S)

B.9.1 Introduction

Hydrogen sulfide (H_2S) is a colorless, acidic gas with a strong unpleasant (rotten egg) odor. At the highest concentrations measured in California, hydrogen sulfide is considered a nuisance.

B.9.2 Air Quality

Peak indicator concentrations are illustrated statewide in Figure B.9-1 from 1980 to 1999. There are increases observed with peak concentrations observed in 1982 (approximately 0.2 ppm) , 1996 (approximately 0.35 ppm) , and for 1991 through 1995 (approximately 0.3 ppm). Again, an analysis of the dependence of peak occurrence on certain sites was conducted. The city of Trona had the highest maximum concentrations. When the Trona site was not included into the analyses, the only increase remaining was for 1982 (Figure B.9-2). The rest of the years from approximately 1985 through 1999 had concentrations of approximately 0.03 ppm.

Trona is the site of an industrial plant that uses salts from the Searles dry lake. The hydrogen sulfide may be attributable to the mining of the salts.

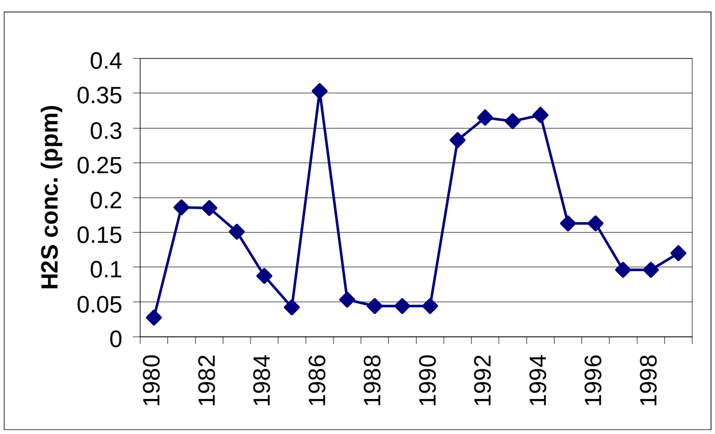

Figure B.9-1 . Peak indicator for hydrogen sulfide (ppm). Statewide.

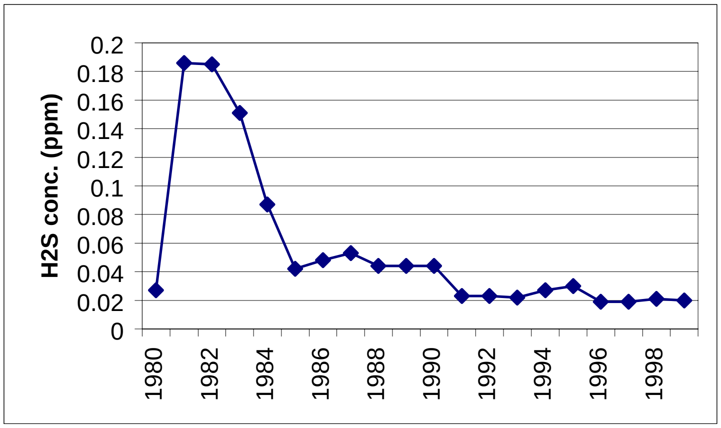

Figure B.9-2. Peak indicator for hydrogen sulfide (ppm). Analyses not including the Trona site.

B.10 Indoor and Outdoor Measurements of Criteria Pollutants

Indoor and outdoor concentrations of criteria pollutants are summarized in Table B.10-1. Parallel indoor and outdoor samples were obtained during each of the reported studies. However, the sampling times are generally longer than the averaging times of the ambient air standards. The one exception was for PM10, which was studied for a 24-hour sampling time. The indoor and outdoor PM10 was investigated in 90 homes in Southern California and there were slightly higher indoor concentrations (median concentrations: indoor = 33 $\mu g/m^3$; outdoor = 29 $\mu g/m^3$).

Table B10-1 Residential Concentrations of Criteria PollutantsRecent California Studies*

Pollutant	Concentrations			Comments	Reference
	Indoor	**Outdoor**	**Averaging Time**		
Ozone	6 ppb (median) 2-16 ppb (25-75 percentile) 50 ppb (99 percentile)	34 ppb (median) 23-51 ppb (25-75 percentile) 89 ppb (99 percentile)	24 hour	Southern California 241 homes	Avol et al., 1996
Particulate Matter (PM10)	98 μ/m^3 (daytime mean) 65 μ/m^3 (nighttime mean)	97 μ/m^3 (daytime mean) 87 μ/m^3 (nighttime mean)	12 hour	Riverside, CA 165 homes, Fall, 1990 PTEAM Study	Clayton et al., 1993 Ozkaynak et al., 1996
	33 μ/m^3 (median) 24-47 μ/m^3 (25-75 percentile) 295 μ/m^3 (99 percentile)	29 μ/m^3 (median) 18-44 μ/m^3 (25-75 percentile) 141 μ/m^3 (99 percentile)	24 hour	Southern California 90 homes	Avol et al., 1996
Fine Particulate Matter (PM2.5)	49 μ/m^3 (daytime mean) 37 μ/m^3 (nighttime mean)	48 μ/m^3 (daytime mean) 52 μ/m^3 (nighttime mean)	12 hour	Riverside, CA, 167 homes, Fall, 1990 PTEAM Study	Clayton et al., 1993 Ozkaynak et al., 1996
	13.7 μ/m^3 (median) 10-23 μ/m^3 (25-75 percentile) 107 μ/m^3 (99 percentile)	10.7 μ/m^3 (median) 7-20 μ/m^3 (25-75 percentile) 77 μ/m^3 (99 percentile)	24 hour	Southern California 67 homes	Avol et al., 1996
Carbon Monoxide	2.93 ppm (arithmetic mean) 0.26-7.45 ppm (range)	5.10 ppm (arithmetic mean) 0.21-16.74 ppm (range)	48 hour	passive samplers statewide monitoring 102 homes	Wilson et al., 1993
Nitrogen Dioxide	25 ppb (arithmetic mean) 0-177 ppb (range)	23 ppb (arithmetic mean) 0-80 ppb (range)	48 hour	passive samplers statewide monitoring 214 homes	Wilson et al., 1993

*Note—Direct comparison with ambient air quality standards can not be made because averaging times are not comparable. Residential indoor data for criteria pollutants are very limited.

References

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Clayton, C.A., R.L. Perritt, E.D. Pellizarri, K.M. Thomas, R.W. Whitmore, L.A. Wallace, H. Ozkaynak, and J.D. Spengler (1993), *Particle Total Exposure Assessment Methodology (PTEAM) Study: Distribution of Aerosol and Elemental Concentrations in Personal, Indoor, and Outdoor Air Samples in a Southern California Community*, Journal of Exposure Analysis and Environmental Epidemiology 3(2): 227-250.

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Ozkaynak, H., J. Xue, R. Weker, D. Butler, P. Koutrakis, and J. Spengler (1996), "The Particle TEAM (PTEAM) Study: Analysis of the Data," August 1996, EPA/600/R-95/098, Volume III of Final Report.

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